The Relationship Between Elbow Position and Grip Strength

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Forty-six graduate students participated in a study to investigate the effect of elbow position on grip-strength measurements. Sixteen males and 30 females, aged 21 to 46 years, participated in the study. Data collection procedures followed standardized grip-strength testing guidelines established by the American Society of Hand Therapists, with the exception of elbow position. Grip-strength measurements were taken with the elbow positioned at 0°, 45°, 90°, and 135° of flexion. The results showed a significantly stronger grip-strength measurement at 0° of flexion and the weakest grip-strength measurement at 135° of flexion. This study supports the use of a standardized method for hand-strength testing. The knowledge that grip-strength measurement is highest when the elbow is fully extended could affect treatment planning.

Grip strength is one of many components to be considered in the examination of hand function. Many of the items included in an upper extremity assessment are based on observation and subjective impressions; however, a grip-strength measurement, when properly taken, can provide objective and quantifiable information regarding hand function. Standardized grip-strength testing procedures have been recommended to provide even greater objectivity of measurement (Fess & Moran, 1981). Additionally, a fundamental consideration in measurement theory is the standardization of methodology for increasing assessment reliability (Ghiselli, Campbell, & Zedeck, 1981). In a clinical setting, however, there are a number of reasons why it may be impossible to follow standardized testing procedures, such as a patient’s inability to tolerate an upright position or the presence of contractures in upper extremity joints.

Various studies have demonstrated that body positioning can affect grip-strength performance. Grip-strength measurements were found to be significantly lower when subjects were supine, compared with grip-strength scores recorded with subjects in a standing or seated position (Teraoka, 1979). Mathiowetz, Rennells, and Donahoe (1985) found that grip-strength scores were higher with the elbow positioned in 90° of flexion as compared with when the elbow was positioned in full extension.

The results of Mathiowetz, Rennells, and Donahoe’s (1985) study pose more questions regarding the influence of elbow position on grip strength. Ninety degrees of elbow flexion resulted in higher grip-strength scores than full elbow extension; however, this study did not encompass what effects other elbow flexion positions may have on grip strength. Perhaps grip-strength scores would increase proportionately with greater degrees of elbow flexion. Additionally, perhaps grip-strength scores would remain the same with any degree of elbow flexion. The nature of the relationship between these two variables is unclear. Without further investigation, the effect of different elbow positions on grip strength will remain unknown.

If grip-strength measures were found to vary depending on elbow position, interpretation of this information could affect treatment planning in the clinical setting. Hand exercises could be performed at the patient’s strongest or weakest position, depending on outcome desired. If a patient is left with weakened grip strength as a result of injury, then task performance may be maximized through adaptation of activities to be performed in the strongest position. Employees who perform tasks that require maximum grip strength could be shown how to position their bodies to achieve the strongest grip ability.

Alternatively, a more in-depth examination of the effects of elbow position on grip strength could result in
findings that are incongruent with statements made by Mathiowetz, Rennells, and Donahoe (1985) and with the recommendations of the American Society of Hand Therapists, which call for standardized arm positioning during grip-strength testing. If various positions of elbow flexion are found to have no effect on grip-strength measurements, then the need for a standard elbow position during grip-strength testing could be eliminated. Clinically, if a patient lacked elbow range of motion and was unable to assume the standard testing position of 90° elbow flexion, then grip-strength scores obtained from any position could still be considered valid.

**Literature Review**

Two studies demonstrated the effect of wrist position on grip strength. Pryce (1980) controlled wrist positions with splints for each of the nine test positions. The elbow was positioned at 90° for each measurement. Results showed no significant differences in grip strength with the wrist positioned at 0° and 15° ulnar deviation and 0° and 15° extension or any combination of these. Grip-strength scores were significantly lower with 15° of wrist flexion or 30° of ulnar deviation or both. In a similar study, Kraft and Detels (1972) described the position of function of the wrist. They found no differences in grip strength for the wrist positioned at 90°, 15°, or 30° of extension and significantly lower strength scores with the wrist positioned in 15° of flexion.

Teraoka (1979) studied the effects of entire body positions on grip strength. He compared grip strength in standing, sitting, and supine positions. All measurements were taken with the elbow fully extended. Results showed significant differences between all three positions, with grip being the strongest when the subject was standing and the weakest when the subject was supine.

Elbow position was found to affect grip strength in a study conducted by Mathiowetz, Rennells, and Donahoe (1985). Grip-strength measurements of 29 female college students were taken with the elbow positioned in full extension and in 90° of flexion. Their results indicated significantly stronger grip-strength measurements in the flexed position when compared with measurements in the fully extended position.

Until Mathiowetz, Rennells, and Donahoe's (1985) study was published, the elbow was not considered to be an important factor in the measurement of grip strength. Kelior, Frost, Silberberg, Iversen, and Cummings (1971) did not control for elbow position when they established norms for grip strength. These norms are no longer considered valid. Mathiowetz, Kashman, et al. (1985) have established grip-strength norms using standardized positioning and instructions as recommended by the American Society of Hand Therapists.

The American Society of Hand Therapists suggested that the position of the upper extremity might influence grip measurement, and it called for a standardized arm position for hand-strength tests (Fess & Moran, 1981). It was recommended that the subject be seated with the shoulder adducted and neutrally rotated, the elbow flexed to 90°, and the forearm and wrist in a neutral position. The Jamar Dynamometer\(^1\) was recommended as the best measure of grip strength by a California Medical Association Committee (Fess & Moran, 1981). The American Society of Hand Therapists recommends that the second handle position of the Jamar Dynamometer be used for grip evaluation and that the mean of three successive trials be recorded as the measure of grip strength (Fess & Moran, 1981).

It has already been shown that, in a small sample of women, grip-strength scores were significantly higher when the elbow was positioned at 90° of flexion than when the elbow was fully extended (Mathiowetz, Rennells, & Donahoe, 1985). The purpose of the present study was to evaluate the effects of four different elbow positions (0°, 45°, 90°, and 135° of flexion) on grip-strength measurements in a larger, more diverse sample. On the basis of Mathiowetz, Rennells, and Donahoe's (1985) results, we hypothesized that grip strength would be greatest at 90° of elbow flexion and that scores would be significantly lower at the three other elbow positions tested.

**Method**

**Subjects**

A sample of 46 graduate students—16 men and 30 women—volunteered to participate in the study. All participants were enrolled in the physical therapy program at the University of Indianapolis. Subjects ranged from 21 to 46 years of age and, by self-report, were free from any neurologic or orthopedic conditions that could affect their grip strength. The dominant hand of each subject was tested.

**Instrument**

A Jamar Dynamometer, set at the second handle position, was used to test each subject's grip strength. The same dynamometer was used throughout the study, and all data were collected by the same examiner (the first author).

**Procedure**

With the exception of elbow positioning, data collection followed the guidelines previously stated by the American Society of Hand Therapists. To control for fatigue, we

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\(^1\)Manufactured by Asimow Engineering Company, 1818 Franklin Street, Santa Monica, California 90404.
varied the order of elbow position by randomly assigning each subject to one of four measurement sequences.

Before testing, the examiner (the first author) demonstrated how to hold the handle of the dynamometer. The same instructions were given for each trial. After the subject was positioned with the dynamometer, the examiner instructed the subject to "squeeze as hard as you can...harder...harder...relax."

The four elbow test positions were marked on a poster. The subjects were seated in a standard-height chair next to the poster and were asked to maintain shoulder adduction while holding their forearm parallel to the mark indicating the test position. Three successive grip measurements were taken in the four elbow flexion positions of 0°, 45°, 90°, and 135°. All three grip measurements in each of the elbow flexion positions were recorded.

Results

The initial step in the analysis of the data from this study involved a 1 x 4 (Grip Strength x Elbow Position) repeated-measures analysis of variance (ANOVA). The results from the omnibus ANOVA were significant [F(3, 135) = 8.58, p < .0001], indicating significant overall differences in grip strength for the elbow positions. The results of this analysis are presented in Table 1.

The significant results from the omnibus analysis necessitated the use of follow-up comparisons with two-tailed t tests to identify specific elbow position differences. The use of the Bonferroni correction for multiple unplanned comparisons resulted in an alpha level of .008 to denote statistically significant between-group differences. These post hoc analyses revealed significant differences between the following elbow position groups: 0° versus 90°; 0° versus 135°; 45° versus 90°; 45° versus 135°. No significant differences were found between the elbow positions of 0° versus 45° or 90° versus 135°.

The mean grip-strength scores for the four elbow position groups are presented in Table 2. As can be seen, the elbow position that resulted in the greatest mean grip strength was 0° of flexion, and the position resulting in the weakest mean grip strength was 135° of flexion.

Discussion

The hypothesis that grip strength would be highest at 90° of elbow flexion and significantly lower at the other three elbow positions was not supported by this study. The highest mean grip-strength measurement was recorded when the elbow was fully extended, that is, at 0° of flexion. Grip-strength scores decreased as the elbow was positioned in greater degrees of flexion; thus, 135° of flexion yielded the weakest grip-strength score. The more extended elbow positions (i.e., 0° and 45° of flexion) differed significantly from the more flexed elbow positions (i.e., 90° and 135° of flexion).

The results of this study contradict the results cited in Mathiowetz, Renfrew, and Donahoe (1985), in which grip strength was found to be significantly higher when the elbow was at 90° of flexion, compared with when the elbow was held in full extension. Although the researchers illustrated their adherence to the American Society of Hand Therapists' recommendations during grip-strength testing with the elbow in 90° of flexion, they did not clarify the position in which the shoulder was held during the fully extended elbow position. The shoulder may have been in 90° of flexion rather than adduction to neutral, which could account for the different results.

From a biomechanical perspective, one might consider length-tension relationships of the muscles involved. Flexor digitorum superficialis is the only primary finger flexor that crosses the elbow joint; therefore, elbow position may affect the strength performance of this muscle. As a muscle is placed in a shortened position, it may become incapable of generating the tension necessary to achieve a functional contraction (Kendall & McCreary, 1983). As the elbow is placed in more degrees of flexion, flexor digitorum superficialis is progressively placed in a more shortened position, thereby placing it at a mechanical disadvantage. This may serve to explain the decrease in grip strength that resulted as degrees of elbow flexion increased.

During the data collection, some participants in this study stated that they felt stronger at 0° of elbow flexion. The data analysis supports these verbal reports. Perhaps this position allows the participants more stabilization. The elbow was allowed to lock into full extension, the shoulder was adducted, and the arm was held close to the

Table 1
Repeated-Measures Analysis of Variance Examining Grip-Strength Differences

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between subjects</td>
<td>3</td>
<td>1755.72</td>
<td>56.33</td>
<td>.0001</td>
</tr>
<tr>
<td>Within subjects</td>
<td>135</td>
<td>31.17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>3</td>
<td>229.61</td>
<td>8.58</td>
<td>.0001</td>
</tr>
<tr>
<td>Residual</td>
<td>135</td>
<td>26.76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>138</td>
<td>455.24</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2
Mean Grip-Strength Scores and Corresponding Standard Deviations for the Four Elbow Position Groups (N= 46)

<table>
<thead>
<tr>
<th>Group</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>0°</td>
<td>82.230</td>
<td>22.331</td>
</tr>
<tr>
<td>45°</td>
<td>80.996</td>
<td>22.640</td>
</tr>
<tr>
<td>90°</td>
<td>78.207</td>
<td>20.196</td>
</tr>
<tr>
<td>135°</td>
<td>77.539</td>
<td>20.414</td>
</tr>
</tbody>
</table>
body. This stable position may have allowed more compensations or overflow to occur, thus producing a higher grip strength.

The results of this study showed significant differences in grip-strength scores with the elbow held in various positions. Therefore, the American Society of Hand Therapists' recommendation of a standardized method for hand-strength testing is certainly supported by this study. Because this study demonstrates that elbow position affects grip-strength scores, the position of the elbow should be an important consideration when one takes grip-strength measurements.

The knowledge that full extension at the elbow produces the highest grip-strength scores can be incorporated into treatment techniques and functional activities. Patients who have weakened grip strength due to illness or injury should be instructed to adapt tasks that require increased grip strength to be performed with the elbow in full extension and the shoulder adducted. For example, such patients may find it easier to open a jar if it is held between their legs while in a seated position to allow elbow extension with shoulder adduction. Repetitive work activities can also be adapted so that upper extremity positioning provides maximal grip strength. This may decrease the effort required and reduce the occurrence of overuse injuries to the upper extremities during repetitive activities.

In future studies, it may be beneficial to look at the results of grip-strength measurements with the elbow held in full extension and the should positioned in 90° of flexion. If full elbow extension produces maximal grip-strength measurements regardless of shoulder position, it may be easier to adapt tasks to be performed with the upper extremity positioned in 90° of shoulder flexion and full elbow extension. The relationship of upper extremity positioning to grip strength is an area that invites more study.

References


